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TWO BOOKS ON ELECTRICITY AND MAGNETISM.

Elements of the Mathematical Theory of Electricity and Magnetism. By J. J. Thomson, M.A., F.R.S., Fellow of Trinity College, Cambridge, and Cavendish Professor of Experimental Physics in the University of Cambridge. Pp. vi + 510. (The Cambridge University Press, 1895.)

Elementary Treatise on Electricity and Magnetism, founded on Joubert's "Traité Elémentaire d'Électricité." By G. C. Foster, F.R.S., Quain Professor of Physics in University College, London; and E. Atkinson, Ph.D., formerly Professor of Experimental Science in the Staff College. Pp. xix + 552. (London: Longmans, Green, and Co., 1896.)

PROF. THOMSON'S book will do good in many ways. Even its title will correct a wrong impression which very generally prevails, to the effect that just so much of the fundamentals and facts of the subject as can be discussed with the aid of a smattering of geometry and algebra, constitutes the truly elementary theory of electricity. On the contrary, students will find that the phrase *Elements of Electricity and Magnetism* really means that satisfactory grounding in essential ideas and their relations which is only possible to a student whose mathematical education has been or is being made adequate to the study of the higher parts of electricity. No important part of the subject is omitted, and of course this brings into play here and there mathematical processes more recondite than some which many practical men seem to shrink from. But there is no obtrusion of purely mathematical discussion; the analysis arises just where it is wanted, to the extent to which it is wanted, and goes no further.

A feature of the book which strikes the reader at once is the use made of the idea of Faraday tubes of force, or rather of electric induction in a dielectric. The distribution of these in the field in different cases of electrification is very fully described and illustrated graphically. This is a matter of very great importance. The examination of students supposed to have received a sound training in elementary electricity has convinced us that very few have a really clear notion of the actual nature of the electrification of a conductor in presence of external and internal charges. Of the dependence on the internal system of charges of the amount and distribution of the charge on the interior surface, and of the nature of the effect of the external system on the distribution on the exterior surface, they seem frequently to have no notion whatever, though they talk glibly about Faraday's ice-pail experiment and his "living" within the large tin-foil covered cube he made and electrified.

A very good elementary account is given of the subject of electric images, and several important particular cases are discussed; for example, that of two unequal spheres intersecting at right angles. This is then converted into the useful problem of the effect of a small hemispherical boss on the capacity of a large sphere.

The effect of dielectrics in the field is then considered, the method of electrical inversion introduced, and the usual problems of mutually influencing spherical surfaces solved. An excellent characteristic of this part of the book, as indeed of the work as a whole, is the working out of clearly formulated expressions which, on insertion of the proper numerical data, give at once the absolute values of important electrical quantities.

What we have said as to the clearness of the discussion of electrostatic theory applies also to the treatment of magnetism and the steady flow of electric currents. The treatment of electrolysis strikes one as rather meagre, but all the statements made are concise and to the point. The table of electrochemical equivalents on p. 282 stands in need of revision, the decimal point seems misplaced in one or two of the numbers.

In the discussion of the magnetic action of currents, Prof. Thomson applies elementary methods successfully to the determination of the magnetic fields of simple systems of currents, and might possibly have gone further in the same direction. But this chapter, the long one which follows on electromagnetic induction, and the thirteenth, which treats of dielectric currents and the electromagnetic theory of light, are the most interesting and important in the book. The first two of these deal with the phenomena and their quantitative expression, the last discusses the production of a magnetic field by the motion of Faraday tubes, Maxwell's theory of the propagation of electromagnetic disturbances, and the verification of this theory by experiment. To show the extent and thoroughness of the discussion, we may mention that the concentration of a rapidly alternating current near the surface of a conductor is explained by general considerations derived from the flow of heat, and, what is still better, is illustrated quantitatively by the case, which is fully worked out, of alternating currents induced in an infinite mass of conducting material bounded by a single plane face, beyond which in the insulating medium the inducing system is situated. This leads to a comparison of the distances to which currents sensibly penetrate in different metals, such as copper and iron, which lie widely apart as regards magnetic permeability.

An account, necessarily of course very short, but good so far it goes, is also given in the chapter on the "Dimensions of Electrical Quantities," of the absolute determination of resistance and the comparison of units. The method of the revolving coil and that of Lorenz are all that are described in the former case, and Maxwell's bridge method (employed so successfully by Prof. Thomson himself in conjunction with Mr. Searle) of finding in electromagnetic units the capacity of a condenser, and thus finding a number for comparison with the electrostatic value, is alone given in the latter case.

Here as elsewhere the author does not shrink from the introduction of a differential equation and its solution. The only alternative is the insertion of the result without proof. The inclusion of the necessary analysis, if it can be done without undue prolixity, is not, as it frequently seems to be regarded, an introduction of "useless mathematics." The justification of the result ought always to be indicated. If the reader cannot understand the proof, he can pass it over; its presence may serve to remind him that besides the mere results there is something

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more to be apprehended and appreciated– the theory by which they have been obtained.

In the chapter on the "Dimensions of Electrical Quantities," the author introduces besides μ and K a third constant p, which may arise in connection with the relation between the current and the magnetic intensity at any point in the field produced, so that 4π times the current flowing through a closed path in a magnetic field is equal to p times the work done in carrying a unit pole once round the path. The dimensions of this constant are of course unknown, and it is only by assuming its dimensions to be zero that the ordinary dimensions of current in electromagnetic units are obtained. There does not seem any distinctly physical ground for bringing in this constant p. The work done in carrying a pole in a complete circuit round a current is independent of the nature of the medium, and hence, justifiably so far as we can see, it may be taken as unity, without involving any neglect of the physical properties of the medium.

The method of the motion of Faraday tubes of electric induction is used in the chapter on "Dielectric Currents and the Electromagnetic Theory of Light." Perhaps it is possible to make too much of this conception; but there can be no question of its great utility as a means of keeping before the mind of the reader the idea of electric and magnetic action as taking place in the medium, and visualising, as it were, what takes place when a condenser is joined to another and partially discharged, when a current flows in a circuit, and the flux of energy in the medium which accompanies all such changes, whether constant or rapidly variable.

The commendation which the work of Prof. J. J. Thomson thoroughly deserves is the due also of that which Prof. Carey Foster and Dr. Atkinson have based on the elementary treatise of M. Joubert. This work has been recast so as to bring it thoroughly into accordance with the later views of electrical theory, and there can be no question of the entire success with which the English authors have performed their task. The book is a thoroughly sound and practical treatise. In it too, though not to the same extent, for its aim is different in some degree, there is a good deal of fairly advanced theory, and like the former work, it shows no shirking or glossing over of difficulties. It contains a more detailed account of the experimental details of the subject than the other work, and this, by the use of a somewhat small but still perfectly clear type, is got in without unduly swelling the volume. The two books read together would form an excellent combination. They are enough to give any competent student a most desirable acquaintance with the essential parts of the main phenomena, and their elementary theory. Such a student would afterwards go easily and rapidly forward with the study of the more elaborate theoretical works, and of the researches which have lately advanced electricity so much—the absolute determinations of electrical constants which have been made by so many experimenters, and the improved science of electrical measurement which these, together with the experimental investigation of the electromagnetic theory of light, and the vast development of practical electricity, have brought into existence.

A. GRAY.

ANNALS OF THE CALCUTTA BOTANIC GARDEN.

Annals of the Royal Botanic Garden, Calcutta. Vol. v. Part I. Pp. 9 + 68, 101 plates. (Calcutta: the Bengal Secretariat Press, 1895.

THE Royal Botanic Garden, Calcutta, has been publishing from time to time a series of "Annals," illustrative of the flora of the continent of India, the adjacent islands, and the contiguous countries. Volume v. of this work was published last year, and Part 1 consists of "A Century of Indian Orchids" by the chief of contemporary botanists, Sir Joseph Hooker. The Calcutta Garden has had the advantage of the services and labours of a long series of eminent botanists. Volume v. of the "Annals" is dedicated to perhaps the most distinguished of them, Roxburgh, superintendent from 1793 to 1814, and author of the "Plants of the Coromandel," the "Hortus Bengalensis," and the "Flora Indica," of whom a portrait and a brief memoir are prefixed. It may be well to recall the names of Roxburgh's successors to show how well botany has been served in connection with these gardens. They have been Wallich, Falconer, Thomson, Anderson, Clarke, and King; the last named, an admirable administrator and a distinguished botanist, being still in charge.

Since Roxburgh's time, that is for more than a century, what Sir Joseph Hooker describes as a "magnificent series of Indian plant-portraits by native artists" has been accumulating in the Calcutta Botanic Garden, of which about a thousand are those of orchids.

"The most important of these collections," says Sir Joseph ("Flora of British India," vol. v. p. 176) "were Malayan, abounding in novelties from Penang, Perak, Singapore and Malacca, made by the late Father Scortechini, . . . by Kunstler (a collector sent from the Calcutta Botanical Gardens by Dr. King), by Curtis Hullett, Wray and Ridley. Important collections were also sent by Mann from Assam, Bhotan, and the Khasia Hills; by Gamble from various parts of India; by Duthie from Garwhal; by Clarke from Sikkim, the Khasia Hills, and Bengal, together with a few from Central India; and by Dr. Trimen from Ceylon."

So little accessible were these drawings, and so little was their value known, that it was not until Sir Joseph Hooker had almost completed, as he mentions in his brief preface to the "Century," the descriptions of Indian orchids for his monumental work, the "Flora of British India," that he obtained, through Dr. King, the loan of the native drawings referred to. Sir Joseph further states that "the inspection of these drawings," coupled with the study of other material received from Calcutta, "necessitated a revision of the characters of the greater portion of the species already described, . . . together with the addition of not a few new species."

With reference to these drawings, the author states that, excellent as they are in many respects, they betray "that tendency to enlarge, which is the besetting sin of Indian botanical artists." Perhaps it is rather the indifference to exact accuracy—a strongly-marked characteristic of all Indian artists—which is in fault. No one who has had to do with Indian workmen can have failed to notice how difficult it is to induce them to recognise the importance of accurate measurements and proportions.

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